

1 CLAIMS

2 1. A method comprising:  
3 providing at least one time-stamped data stream that is to be rendered in  
4 accordance with data stream timestamps; and  
5 synchronizing said at least one time-stamped data stream relative to a  
6 reference by adjusting one or more timestamps of said at least one time-stamped  
7 data stream.

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9 2. The method of claim 1, wherein the reference comprises another  
10 time-stamped data stream.

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12 3. The method of claim 1, wherein the reference comprises a reference  
13 clock.

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15 4. The method of claim 1, wherein the act of synchronizing comprises  
16 doing so periodically.

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18 5. The method of claim 1, wherein the act of synchronizing comprises  
19 determining whether said at least one time-stamped data stream is within a defined  
20 tolerance and, if not, performing said act of synchronizing.

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22 6. The method of claim 1, wherein said at least one time-stamped data  
23 stream comprises a video stream.

1           7.    The method of claim 1, wherein said at least one time-stamped data  
2 stream comprises an audio stream.

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4           8.    The method of claim 1, wherein said at least one time-stamped data  
5 stream comprises a video stream and an audio stream.

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7           9.    A method comprising:  
8           providing a filter graph comprising multiple filters, the filter graph being  
9 configured to process multiple timestamped data streams for rendering the data  
10 streams in accordance with data stream timestamps; and  
11           synchronizing said at least one time-stamped data stream relative to a  
12 reference by adjusting one or more timestamps of said at least one time-stamped  
13 data stream.

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15           10.   The method of claim 9, wherein the act of synchronizing comprises  
16 instructing one or more of the filters to adjust at least one timestamp associated  
17 with at least one data sample of one or more of the data streams.

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19           11.   The method of claim 10, wherein the act of instructing comprises  
20 instructing one or more decoder filters to adjust at least one timestamp associated  
21 with at least one data sample.

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23           12.   The method of claim 9, wherein the reference comprises another  
24 time-stamped data stream.

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1           13.    The method of claim 9, wherein the reference comprises a reference  
2 clock.

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4           14.    The method of claim 9, wherein the act of synchronizing comprises  
5 doing so periodically.

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7           15.    The method of claim 9, wherein the act of synchronizing comprises  
8 determining whether said at least one time-stamped data stream is within a defined  
9 tolerance and, if not, performing said act of synchronizing.

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11          16.    One or more computer-readable media comprising instructions  
12 which, when executed by one or more processors, cause the one or more  
13 processors to implement the method of claim 9.

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15          17.    A method comprising:  
16           providing a filter graph comprising multiple filters, the filter graph being  
17 configured to process multiple timestamped data streams for rendering the data  
18 streams in accordance with data stream timestamps;

19           providing a synchronization module associated with the filter graph, the  
20 synchronization module being configured to:

21               query individual filters of the filter graph to ascertain input  
22 timestamp-to-output timestamp mappings,

23               compute adjustments that are to be made to output timestamps in  
24 order to synchronize the data streams, and  
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1           instruct individual queried filters to adjust their output timestamps in  
2           accordance with computed adjustments;  
3           querying individual filters of the filter graph, using the synchronization  
4           module, to ascertain input timestamp-to-output timestamp mappings;  
5           computing, based on the ascertained input timestamp-to-output timestamp  
6           mappings, adjustments that are to be made to output timestamps in order to  
7           synchronize the data streams; and  
8           synchronizing the data streams by instructing one or more of the queried  
9           filters to adjust their output timestamps in accordance with the computed  
10          adjustments.

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12          **18.**    The method of claim 17, wherein the act of synchronizing comprises  
13          doing so periodically.

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15          **19.**    The method of claim 17, wherein the act of synchronizing comprises  
16          determining whether the multiple time-stamped data streams are within a defined  
17          tolerance and, if not, performing said act of synchronizing.

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19          **20.**    The method of claim 17, wherein the act of querying comprises  
20          querying individual filters for a current input timestamp and a current output  
21          timestamp.

1           **21.**    The method of claim 20, wherein the act of computing comprises:  
2           extrapolating at least one curve characterizing the timestamp mappings for  
3           at least one of the timestamp mappings to a defined point corresponding to a  
4           common input timestamp; and  
5           computing said adjustments based on the extrapolated line(s).

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7           **22.**    The method of claim 21, wherein the act of extrapolating comprises  
8           performing a linear extrapolation.

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10          **23.**    The method of claim 21, wherein the defined point comprises the  
11          largest value of an input timestamp returned by the act of querying.

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13          **24.**    The method of claim 21, wherein the act of computing comprises  
14          computing a skip value by taking the difference between the largest output  
15          timestamp value at the common input timestamp and the output timestamp value  
16          for said at least one curve at the common input timestamp.

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18          **25.**    The method of claim 24, wherein the act of instructing comprises  
19          instructing one or more filters to jump their output timestamp values by an  
20          associated skip value at the common input timestamp.

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22          **26.**    An architecture comprising:  
23          a filter graph comprising multiple filters, the filter graph being configured  
24          to process multiple timestamped data streams for rendering the data streams in  
25          accordance with data stream timestamps; and

1 a synchronization module associated with the filter graph, the  
2 synchronization module being configured to:

3 query individual filters of the filter graph to ascertain input  
4 timestamp-to-output timestamp mappings,

5 compute adjustments that are to be made to output timestamps in  
6 order to synchronize the data streams, and

7 instruct the queried filters to adjust their output timestamps in  
8 accordance with its adjustment computations.

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10 **27.** The architecture of claim 26, wherein the synchronization module is  
11 configured to periodically instruct one or more of the queried filters to adjust their  
12 output timestamps.

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14 **28.** The architecture of claim 26, wherein the synchronization module is  
15 configured to determine whether the multiple time-stamped data streams are  
16 within a defined tolerance and, if not, at least instruct one or more of the queried  
17 filters to adjust their output timestamps.

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19 **29.** The architecture of claim 26, wherein the synchronization module is  
20 configured to query individual filters for a current input timestamp and a current  
21 output timestamp.

1           **30.**    The architecture of claim 29, wherein the synchronization module is  
2 configured to compute adjustments by:

3           extrapolating at least one curve characterizing the timestamp mappings for  
4 at least one of the timestamp mappings to a defined point corresponding to a  
5 common input timestamp; and

6           computing said adjustments based on the extrapolated line(s).

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8           **31.**    The architecture of claim 30, wherein the synchronization module is  
9 configured to linearly extrapolate said at least one curve.

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11           **32.**    The architecture of claim 30, wherein the defined point comprises  
12 the largest value of an input timestamp returned by querying the one or more  
13 filters.

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15           **33.**    The architecture of claim 30, wherein the synchronization module is  
16 configured to compute adjustments by taking the difference between the largest  
17 output timestamp value at the common input timestamp and the output timestamp  
18 value for said at least one curve at the common input timestamp.

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20           **34.**    The architecture of claim 33, wherein the synchronization module is  
21 configured to instruct one or more filters to jump their output timestamp values by  
22 an associated skip value at the common input timestamp.

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35. One or more computer-readable media having computer-readable instructions thereon which, when executed by one or more processors, cause the one or more processors to:

- query one or more filters configured to process timestamped data streams for each filter's input timestamp-to-output timestamp mapping;
- receive responses from the queried filters;
- extrapolate one or more lines characterizing an individual mapping to a selected input timestamp value;
- calculate a skip value for one or more of the lines, a skip value representing a value by which the output timestamps for a given filter are to be corrected; and
- provide instructions to one or more of the filters to adjust their output timestamps in accordance with an associated skip value.

36. The computer-readable media of claim 35, wherein the instructions cause the one or more processors to query the one or more filters for each filter's data stream playback rate.

37. The computer-readable media of claim 35, wherein the instructions cause the one or more processors to query one or more decoders filters.

38. The computer-readable media of claim 35, wherein the instructions cause the one or more processors to linearly extrapolate the one or more lines.



1           **39.**    The computer-readable media of claim 35, wherein the selected  
2 input timestamp value comprises a current input timestamp value for one of the  
3 filters.

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5           **40.**    The computer-readable media of claim 35, wherein the selected  
6 input timestamp value comprises a future input timestamp value.

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8           **41.**    One or more computer-readable media having computer-readable  
9 instructions thereon which, when executed by one or more processors, cause the  
10 one or more processors to:

11               define a skip value tolerance that can be used to ascertain when  
12 synchronization processing of multiple data streams should take place;

13               ascertain whether any input timestamp-to-output timestamp mappings  
14 associated with any of the multiple data streams meet or exceed the skip value  
15 tolerance; and

16               synchronize the multiple data streams if any input timestamp-to-output  
17 timestamp mappings meet or exceed the skip value tolerance.

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19           **42.**    The computer-readable media of claim 41, wherein the instructions  
20 cause the one or more processors to synchronize to a common data stream.

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22           **43.**    The computer-readable media of claim 41, wherein the instructions  
23 cause the one or more processors to synchronize to a reference clock.  
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1           **44.**    The computer-readable media of claim 41, wherein one of the  
2 multiple data streams comprises a video stream.

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4           **45.**    The computer-readable media of claim 41, wherein one of the  
5 multiple data streams comprises an audio stream.

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7           **46.**    The computer-readable media of claim 41, wherein one of the  
8 multiple data streams comprises a video stream and another of the multiple data  
9 streams comprises a video stream.  
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